



# **Washington Airport Pavement Management System**

## **Pavement Management Manual**



# **Washington Airport Pavement Management System**

## **Pavement Management Manual**

**Prepared for**



**Washington State  
Department of Transportation**

WSDOT Aviation  
3704 172nd Street NE, Suite K2  
Arlington, WA 98223  
Phone: (360) 651-6300 or (800) 552-0666  
Fax: (360) 651-6319  
[www.wsdot.wa.gov/aviation](http://www.wsdot.wa.gov/aviation)

and



Federal Aviation Administration  
Seattle Airports District Office  
1601 Lind Avenue S.W., Suite 250  
Renton, WA 98055

**Prepared by**



Applied Pavement Technology, Inc.  
3001 Research Road, Suite C  
Champaign, Illinois 61822  
Phone 217 398 3977

The preparation of this document may have been supported, in part, through the Airport Improvement Program financial assistance from the Federal Aviation Administration (Project Number 3-53-0000-01, 3-53-0000-03 and 3-53-0000-04) as provided under Title 49, United States Code, section 47104. The contents do not necessarily reflect the official views or policy of the FAA. Acceptance of this report by the FAA does not in any way constitute a commitment on the part of the United States to participate in any development depicted therein nor does it indicate that the proposed development is environmentally acceptable in accordance with appropriate public laws.

## TABLE OF CONTENTS

PREFACE .....	iii
1. INTRODUCTION TO PAVEMENT MANAGEMENT .....	1-1
PAVEMENT MANAGEMENT OVERVIEW .....	1-1
Pavement Management Historical Perspective .....	1-1
Levels of Pavement Management .....	1-2
Network-Level Pavement Management .....	1-2
Project-Level Pavement Management .....	1-3
APMS Components .....	1-3
Network Inventory .....	1-3
Condition Assessment .....	1-3
Database .....	1-4
Data Analysis .....	1-4
System Outputs .....	1-4
Feedback Loop .....	1-4
WASHINGTON APMS PROCESS .....	1-5
Records Review .....	1-5
Pavement Network Definition and Map Generation .....	1-5
PAVEMENT CONDITION ASSESSMENT .....	1-6
Database Development .....	1-7
APMS Customization .....	1-7
Data Analysis .....	1-7
Report Preparation .....	1-7
SUMMARY .....	1-7
2. MONITORING PAVEMENT CONDITION .....	2-1
PUBLIC LAW 103-305 .....	2-1
CONDITIONS REQUIRING IMMEDIATE ATTENTION .....	2-4
Asphalt Distress Types .....	2-4
Alligator (Fatigue) Cracking .....	2-4
Bleeding .....	2-5
Depressions .....	2-6
Longitudinal and Transverse Cracking .....	2-7
Patching .....	2-8
Raveling and Weathering .....	2-9
Shoving of AC Pavements by PCC Pavements .....	2-10
Slippage Cracking .....	2-11
Swell .....	2-12
PCC Distress Types .....	2-13
Blow-Ups .....	2-13
Corner Break .....	2-14
Longitudinal, Transverse, and Diagonal (LTD) Cracking .....	2-15
Durability (D) Cracking .....	2-16
Patching .....	2-17
Scaling, Map Cracking, and Crazeing .....	2-18
Faulting/Settlement .....	2-19
Shattered Slabs .....	2-20

---

3. DEVELOPING AND IMPLEMENTING A MAINTENANCE AND REHABILITATION PLAN FOR YOUR AIRPORT .....	3-1
DEVELOPING A MAINTENANCE AND REHABILITATION PLAN .....	3-1
Determine Current Pavement Inventory and Pavement Conditions .....	3-1
Identify Cause of Deterioration and Appropriate Repair Action .....	3-5
Develop Short-Term Localized Maintenance Plan .....	3-5
Develop Long-Term Rehabilitation Plan .....	3-7
Develop Procedure for Monitoring Pavement Condition and Tracking Maintenance .....	3-9
Request Funding for Pavement Maintenance and Rehabilitation .....	3-11
Federal Funding .....	3-11
General Aviation Non-Primary Entitlement Program (NPE) .....	3-11
Airport Improvement Program (AIP) Grant .....	3-11
State Funding .....	3-12
Implement the Plan .....	3-12

## PREFACE

Washington's airport system represents a tremendous capital investment and plays a critical role in the economic health of the state. As this system has aged, the upkeep of the existing pavements has become increasingly important. Therefore, the Washington State Department of Transportation (WSDOT) Aviation maintains a statewide airport pavement management system (APMS) to provide the airports, the State, and the FAA with the pavement information and analytical tools that can help them identify pavement-related needs, optimize the selection of projects and treatments over a multi-year period, and evaluate the long-term impacts of decisions made regarding the Washington airport pavement infrastructure.

The principal objective for the APMS is to assess the relative condition of pavements for selected Washington airports in the Washington State Airport System Plan (WSASP) and the Federal Aviation Administration (FAA) National Plan of Integrated Airport Systems (NPIAS). The APMS can be used as a tool to identify system needs, make programming decisions for funding, provide information for legislative decision making, and assist local jurisdictions with planning decisions.

As part of the State's APMS, Applied Pavement Technology, Inc. (APTech) has prepared this *Pavement Management Manual* for WSDOT Aviation and the individual airports to use in conjunction with their pavement management activities. This work is being funded with a grant from the FAA. The *Pavement Management Manual* is designed to be used in conjunction with the individual airport reports delivered to each airport included in the State's APMS. It is divided into the following three sections:

Section 1 – provides an overview of the pavement management process and the Pavement Condition Index (PCI) procedure.

Section 2 – provides guidance on what an airport needs to do to remain in compliance with Public Law 103-305. While this law only applies to NPIAS airports, it is highly recommended that non NPIAS airports also undertake the activities prescribed in it since they are highly beneficial. Section 2 also contains information on distress types/severity combinations that warrant immediate action and/or notification of WSDOT and the FAA of conditions.

Section 3 – describes how an airport sponsor can use its individual airport report to plan for pavement maintenance and rehabilitation projects.

It is important to note that the role of the State, as an advocate to airports, is not to supplant the role of the airport sponsor. It is not the role of WSDOT to serve in an enforcement capacity nor is it the role of WSDOT to bring an airport into compliance with state or federal requirements. The role of WSDOT is to identify the pavement needs and recommended process of preserving the pavements within the WSASP and NPIAS. The cities, counties, and port districts provide the key policy and financial decisions necessary for preserving airports pavements in Washington State.

# **SECTION 1**

## **PAVEMENT MANAGEMENT PROCESS**

## 1. INTRODUCTION TO PAVEMENT MANAGEMENT

Airport sponsors and aviation agencies are responsible for a large capital investment at airports – the pavement infrastructure. Careful management of the pavements has become increasingly important as pavements have aged, funding levels have become more restrictive, and the competition for pavement rehabilitation project funding has heightened. Airports and state aviation agencies are better able to address these issues if they have tools at their disposal to assist in: 1) determining their pavement needs, 2) optimizing the selection of projects and treatments over a multi-year period, and 3) evaluating the long-term impacts of their project priorities. The implementation of an airport pavement management system (APMS) can provide many of the tools necessary to perform these important activities.

### **Pavement Management Overview**

Pavement management is a systematic method of: 1) assessing current pavement conditions, 2) determining maintenance and rehabilitation needs, and 3) prioritizing these needs to make the best use of anticipated funding levels. An APMS is typically a computerized software program, such as Micro PAVER, that facilitates the storage and analysis of airport pavement-related data.

### **Pavement Management Historical Perspective**

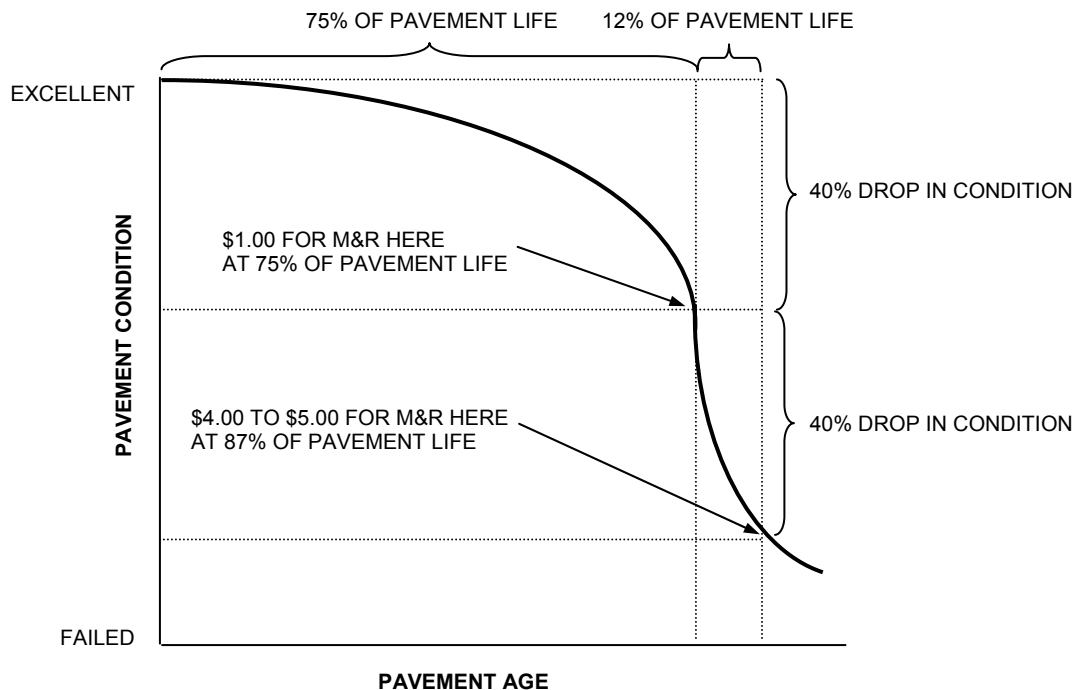
The concept of pavement management has evolved significantly since its 1970s inception. The intent of original pavement management practitioners was to develop an objective approach to do the following: 1) assess current pavement condition, 2) predict future pavement condition, and 3) prioritize pavement rehabilitation needs over a multi-year period in an effort to optimize the use of available funding.

As standardized condition survey techniques came into place, more information regarding the cause of pavement deterioration became available. This information was then used to readily assess available repair alternatives and select the better repair strategy. This approach greatly improved the effectiveness of selected rehabilitation treatments since they were now being chosen to address the deficiencies present and prevent their recurrence.

Finally, as computerized pavement management systems became available, an even more sophisticated level of analysis became possible. With today's systems, the results of the pavement condition surveys are used not only to assess current pavement conditions but to identify pavement deterioration trends as well. This capability provides the agency with the ability to forecast future pavement conditions. As a result, agencies are able to assess the long-term impacts of decisions made today on future network conditions and identify the optimal time for repair so that funding can be scheduled in advance of the forecasted need.

The importance of identifying not only the best repair alternative but also the optimal time of repair has been documented in US Army Corps of Engineers, Construction Engineering Laboratory (USACERL) Technical Report M-90/05 and is summarized in the following figure. This figure shows that over the first 75% of the pavement life, approximately 40% of the pavement condition deterioration takes place. After this point, the pavement deteriorates much

faster with the next 40% drop in pavement condition occurring over the next 12% of the pavement life. The financial impact of delaying repairs until the second drop in pavement condition can mean repair expenses 4 to 5 times higher than repairs triggered over the first 75% of the pavement life.



M&R = major rehabilitation.

Typical pavement condition life cycle.  
(Based on figure from USACERL Technical Report M-90/05)

### Levels of Pavement Management

Pavement management provides information for decision making at two distinct levels: **network-level** management and **project-level** management.

#### *Network-Level Pavement Management*

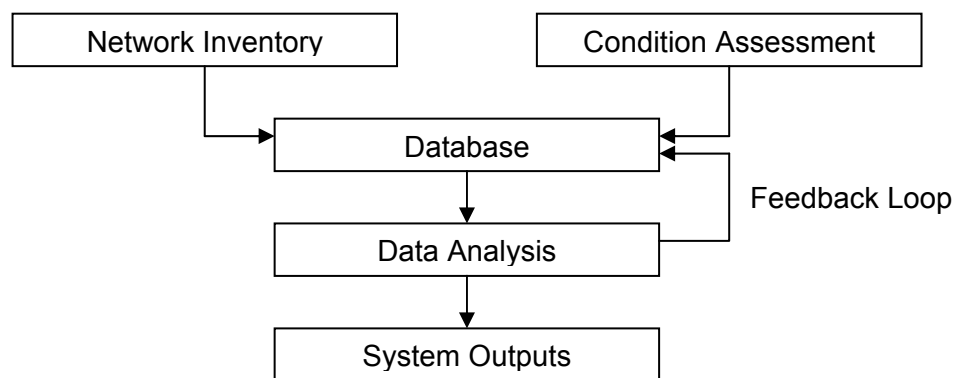
Network-level pavement management involves the evaluation of all pavements under an agency's jurisdiction to determine future maintenance and rehabilitation needs for the development of multi-year budget plans. The level of pavement evaluation required to perform this type of management involves visually inspecting representative samples of pavement. Based on the analysis of the network-level pavement condition data, candidate pavement areas are selected for potential maintenance and rehabilitation (M&R) projects. General unit costs are used at the network level and specific designs are not developed. The Washington APMS operates at the network level.

## *Project-Level Pavement Management*

Once a pavement area has been identified as a candidate for repair (such as a runway rehabilitation project), it is then evaluated at the project level. This level of analysis requires higher inspection sampling rates. Additional testing, such as nondestructive testing and coring, is often used during project-level analysis to provide additional knowledge about pavement condition and distress mechanisms. Based on the results of project-level analysis, specific treatments (such as an overlay) can be selected for the candidate pavement areas and more accurate cost estimates can be developed.

## APMS Components

An APMS is comprised of six basic components, as shown in the following figure.



## *Network Inventory*

Network inventory is used to define the physical characteristics of the pavements being managed. Typically, the collected information includes construction, maintenance, traffic, and condition data. It is important to keep two guidelines in mind when determining the extent of historical information to include in the inventory. First, the data should be accessible so that substantial time is not invested in a search of construction records. Secondly, the collected information should serve a purpose. Establishing a network inventory, although often a tedious and labor-intensive process, is the foundation for the APMS.

## *Condition Assessment*

Pavement management decisions depend on some method of pavement evaluation. The method selected to evaluate pavement condition is extremely important because it is the basis of all recommendations. For that reason, it is critical to select an objective and repeatable procedure so that APMS recommendations are reliable.

Pavement managers must evaluate their needs when determining not only the type of condition data to collect but also how often to collect the data. For example, an agency experiencing rapid deterioration rates may elect to survey their pavements more frequently than the average organization. Each agency must carefully evaluate their own circumstances to ensure that the data collection aspects of their APMS match both their needs and financial means.

## *Database*

Once the network inventory and pavement condition assessment data have been collected, a database can be established to use the information. Although a manual filing system may be possible for a small network, the efficiency and cost-effectiveness of storing data on a computer makes an automated database the most practical alternative, especially when a comprehensive APMS is desired.

## *Data Analysis*

Data analysis can occur at the network- or project-level. At the network level, potential rehabilitation needs of the entire network are evaluated and prioritized for planning and scheduling budget needs over a multi-year period. The objective of network level analysis is to evaluate rehabilitation needs for a future time period and prioritize project lists so that the agency makes the best use of the limited funds available for M&R. After the planning and programming decisions have been made during the network-level analysis, the information in the database can be used to supplement a project-level analysis. At the project-level, each individual project is investigated in detail to determine the appropriate rehabilitation treatment.

## *System Outputs*

Results of planning analyses are useful only if the information provided can be easily conveyed. There are a number of different methods for presenting the results of the analyses discussed in the previous sections including tables, reports, graphs and maps.

Often, engineers prefer seeing detailed information in the form of comprehensive reports. However, because of the volume of information contained in these types of reports they might not be effective for quickly conveying information to managers or airport sponsors. Instead, graphical reports are more effective for people who need to quickly evaluate large amounts of data.

Many airport agencies have found value in linking their APMS to their computer-aided drafting (CAD) maps in order to display information through color-coded maps. As with the graphical display, this capability has greatly enhanced the usefulness of the APMS to managers and sponsors who need to convey a lot of information in a short period of time. Map links are perhaps most useful in displaying the funded projects in each year of the analysis or for displaying the results of a condition assessment. The Micro PAVER pavement management software, used by WSDOT and the FAA, provides a direct GIS link between CAD maps and pavement management database to facilitate the development of this type of output.

## *Feedback Loop*

An often-overlooked component of an APMS is the development of a feedback loop. The feedback loop establishes a process by which actual performance and cost data are input back into the models used in the pavement management analysis. For example, the APMS may use models that estimate the life of an asphalt overlay at 12 years. Actual performance data may show that the life of the agency's overlays is closer to 8 to 10 years. This type of information should be used to update the pavement management models so that the system recommendations remain reliable and become better with time.

## Washington APMS Process

The following activities were completed during the Washington APMS implementation in 1999/2000 and the subsequent update in 2005/2006:

- Records review,
- Pavement network definition and map generation,
- Pavement condition assessment,
- Database development,
- APMS customization,
- Data analysis,
- Report preparation.

### Records Review

Before initiating fieldwork, a comprehensive review of existing records was undertaken to collect data needed to conduct the APMS analysis. Records pertaining to construction history, maintenance history, and as-built pavement layer thickness were gathered and reviewed. The record information was often supplemented by information obtained through telephone interviews with airport staff and fixed based operators (FBO). The collected information was used to accurately divide the airport pavements into distinct pavement sections and to identify pavement performance trends upon which future maintenance and rehabilitation requirements were based.

### Pavement Network Definition and Map Generation

Using information from the records review, the pavement system at each airport was divided into units called branches (sometimes referred to as facilities), sections (sometimes referred to as features), and sample units.

A branch is a single entity that serves a distinct function. For example, a runway is considered a branch because it serves the single function of allowing aircraft to take off and land. For airfields, a branch typically represents an entire runway, taxiway, apron, or helipad.

Because of the disparity of pavement-related characteristics that can occur within a branch, branches are further subdivided into sections. A section is an area of the pavement that has uniform construction history, pavement structure, traffic patterns, and condition throughout its entire area.




For inspection purposes, pavement sections were further subdivided into sample units. A sample unit for jointed portland cement concrete (PCC) pavement is  $20 \pm 8$  slabs; a sample unit for asphalt concrete-surfaced (AC) airside pavement is an area of  $5000 \pm 2000$  square feet.

Maps were prepared by CivilTech and APtech for each airport. These maps included network definitions maps, work history maps, pavement condition maps, and recommended work plan maps.

## Pavement Condition Assessment

APTech, with assistance from CH2M HILL, inspected the pavements at Washington airports using the Pavement Condition Index (PCI) procedure, which was developed by the US Army Corps of Engineers, Construction Engineering Research Laboratory. The PCI procedure is described in Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5380-6A, *Guidelines and Procedures for Maintenance of Airport Pavements*, and ASTM Standard D5340, *Standard Test Method for Airport Pavement Condition Index Surveys*.

The PCI is used to indicate the condition of the operational surface of the pavement and, to some extent, the structural integrity of the pavement. During a PCI survey, distress type, distress severity, and distress quantity are recorded and analyzed. This information is used to calculate the PCI value of the section. The final calculated PCI value is a number from 0 to 100, with 100 representing a pavement in excellent condition, as illustrated in the following figure.

Representative Pavement Surface	PCI
	100
	60
	5

Visual representation of PCI scale.

The types of distress identified during the PCI inspection provide insight into the cause of pavement deterioration. PCI distress types are characterized as load-related (such as alligator cracking on AC pavements or corner breaks on PCC pavements), climate/durability-related (such as weathering [climate-related on AC pavements] and D-cracking [durability-related on PCC pavements]), and other (distress types that cannot be attributed solely to load or climate/durability). Understanding the cause of distress helps in selecting a rehabilitation alternative that corrects the cause and thus eliminates its recurrence.

During the PCI survey, photographs of each branch were taken. These photographs provide an overview of typical conditions, and cover any unusual or severe distress identified in the field.

### Database Development

As described in previous sections, the inventory data and the pavement condition data provide the foundation of an APMS. All collected information was entered into WSDOT's Micro PAVER database. This database contains information on the physical characteristics (such as pavement dimensions, surface types, ages, and so on) of each airport's pavement system as well as detailed work history and pavement distress information.

### APMS Customization

In order for Washington's APMS to be a useful tool, it must reflect the policies, practices, and procedures of WSDOT Aviation and the FAA. Therefore, APTech customized the Micro PAVER software through such activities as the development of pavement performance models, the development of prioritization guidelines, and the identification of maintenance policies and major rehabilitation costs.

### Data Analysis

Once Micro PAVER was customized to reflect conditions within WSDOT and the FAA, the collected information was analyzed. Data analysis included: evaluation of visual distress data (e.g., current PCI, cause of deterioration, rate of deterioration); prediction of future pavement condition; development of an annual maintenance plan; and preparation of a 7-year rehabilitation program that outlines the improvement needs for each pavement section.

### Report Preparation

The final deliverables of the project included individual airport reports for each airport and a statewide summary report. A separate report for the airports in Puget Sound was also prepared.

## **Summary**

An APMS is a tool for use by airport agencies responsible for preserving the condition of pavement networks within an environment of increased competition for available funds. When used appropriately, an APMS can provide the information necessary to make cost-effective decisions about the rehabilitation of the pavement network while also providing the necessary information for the users to develop an understanding of the long-term impacts of the decisions being made. An APMS may also assist in conveying the resulting information to the decision-makers that control budget allocations.

## **SECTION 2**

# **MONITORING PAVEMENT CONDITION**

## 2. MONITORING PAVEMENT CONDITION

The pavements at an airport directly impact the safety of operations and represent a very large capital investment that should be carefully preserved. Therefore, it is critical for each airport sponsor to actively monitor the condition of the pavement infrastructure, and to track pavement maintenance needed and completed at an airport. This section of the manual provides information on what airports need to do to remain in compliance with Public Law 103-305.

While this law only applies to NPIAS airports, it is highly recommended that non NPIAS airports also undertake the activities prescribed in it since they are highly beneficial. In addition, this section of the manual provides guidance on what pavement conditions require immediate attention and/or notification of WSDOT and the FAA.

### Public Law 103-305

According to Public Law 103-305, any airport requesting Federal funds for a project to replace or reconstruct a pavement under the airport grant assistance program must have implemented a pavement maintenance program. The law states that airport sponsors must provide assurances or certifications that an airport has implemented an effective airport pavement maintenance management system (PMMS) before the airport will be considered for funding of pavement replacement or reconstruction projects. To be in full compliance with the Federal law, the PMMS must include the following components at a minimum: pavement inventory, pavement inspections, record keeping, information retrieval, and program funding. These components are described in the following excerpt from FAA AC 150/5380-6A:

**1. Pavement Inventory.** *The following must be depicted in an appropriate form and level of detail:*

- a. Location of all runways, taxiways, and aprons*
- b. Dimensions*
- c. Type of pavement*
- d. Year of construction or most recent major rehabilitation*
- e. Whether Federal financial assistance was used to construct, reconstruct, or repair the pavement.*

### **2. Inspection Schedule.**

**a. Detailed Inspection.** *Trained personnel must perform a detailed inspection of airfield pavements at least once a year. If a history of recorded pavement deterioration in the form of a Pavement Condition Index (PCI) survey as set forth in ASTM D5340, Standard Test Method for Airport Pavement Condition Index Surveys, is available, the frequency of inspections may be extended to 3 years.*

**b. Drive-By Inspection.** *A drive-by inspection must occur a minimum of once per month to detect unexpected changes in the pavement condition.*

**3. Record Keeping.** *The airport must record and keep on file for a minimum of 5 years complete information about all detailed inspections and maintenance performed. The types of distress, their locations, and remedial action, scheduled or performed, must be documented. The minimum information to be recorded is listed below:*

- a. Inspection date*
- b. Location*
- c. Distress types*
- d. Maintenance scheduled or performed*

*For drive-by inspections, records must include the date of inspection and any maintenance performed.*

**4. Information Retrieval.** *An airport sponsor may use any form of record keeping it deems appropriate, so long as the information and records produced by the pavement survey can be retrieved as necessary for any reports required by the FAA.*

**5. Program Funding.** *The program should identify funding and other resources available to provide remedial and preventive maintenance activities.*

Through WSDOT's APMS project, it has provided airports within the state with an excellent basis for meeting the requirements of this law. These airports now have a complete pavement inventory and a detailed inspection. To remain in compliance with the law, NPIAS airports will also need to undertake monthly drive-by inspections of pavement conditions and track pavement-related maintenance activities.

The form provided on the following page can be used for the required monthly inspections. While only required for NPIAS airports, it is highly recommended that non NPIAS airports perform these inspections as well and keep records of pavement conditions and maintenance and rehabilitation work completed at the airport.

# **PAVEMENT INSPECTION REPORT**

Inspected By: \_\_\_\_\_

Date Inspected:\_\_\_\_\_

Inspection Record		Maintenance Action		
Location	Distress Description/Dimensions/Severity/Recommended Action	Description of Repair	Date Performed	Cost

## Conditions Requiring Immediate Attention

Some pavement distress types warrant immediate remedial action and/or notification of the FAA and WSDOT as to pavement condition. These are situations that can lead to tire damage, foreign object damage (FOD), loss of friction, or hydroplaning. Following is a description of situations that you should correct immediately or contact the FAA and WSDOT about their existence. Obviously, the occurrences of these distresses on runways or other areas where pilots are maneuvering, especially at high speeds, are more critical.

### Asphalt Distress Types

The following is a list of the distress type/severity combinations for asphalt concrete surfaced pavements that warrant immediate attention and/or notification of the WSDOT and the FAA about the problem. There are many other PCI distresses/severity combinations that are not mentioned herein that may be found on Washington airfields. For a complete listing of airfield PCI distresses, please refer to ASTM D 5340 or FAA AC 150/5380-6A.

#### *Alligator (Fatigue) Cracking*

Alligator (fatigue) cracking appears as a series of interconnecting cracks caused by fatigue failure of the AC surface. The fatigue failure is most often the result of repeated traffic loading. After repeated traffic loading, the cracks connect, forming many-sided, sharp-angled pieces that develop a pattern resembling an alligator's skin. At the high severity level the pieces are well defined and spalled at the edges; there is definite FOD potential. If extensive the only recourse is to overlay or reconstruct the pavement. If localized, full depth patching is an appropriate repair. The following photograph illustrates what alligator cracking looks like at the high severity level.



High severity alligator cracking.

### *Bleeding*

Bleeding is a film of bituminous material on the pavement surface that creates a shiny, glass like, reflecting surface that usually becomes quite sticky. Bleeding is caused by excessive amounts of asphaltic cement or tars in the mix or low air void content, or both. It occurs when asphalt fills the voids of the mix during hot weather and then expands out onto the surface of the pavement. Since the bleeding process is not reversible during cold weather, asphalt or tar will accumulate on the surface. At its most severe, bleeding can result in a severe reduction in skid resistance.

If bleeding is extensive and severe, as shown in the following photograph, the asphalt layer should be removed and replaced.



Extensive bleeding.

### *Depressions*

Depressions are localized pavement surface areas having elevations slightly lower than those of the surrounding pavement. Depressions can be caused by settlement of the foundation soil or can be “built up” during constructions. Depressions cause roughness and when filled with water of sufficient depth, could cause hydroplaning of aircraft. High severity depressions in areas where an aircraft is trying to maneuver at high speeds should be patched. An example of a high severity depression is shown in the following photograph.



High severity depression.

### *Longitudinal and Transverse Cracking*

Longitudinal cracks are parallel to the pavement's centerline. Transverse cracks are approximately perpendicular to the pavement's centerline or direction of laydown. At the high severity level, the cracks are severely spalled and pieces are loose or missing causing definite FOD potential. These cracks need to be sealed. The following photograph shows a crack that needs immediate attention.



High severity longitudinal crack.

### *Patching*

At high severity, a patch is badly deteriorated and affects riding quality significantly or has high FOD potential. High severity patches need to be replaced to avoid FOD and/or tire damage potential. A photograph of a high severity patch follows.



High severity patch.

### *Raveling and Weathering*

Raveling and weathering are the wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt or tar binder. Both may indicate that the asphalt binder has hardened significantly. At high severity the aggregate or binder, or both, has worn away causing a high FOD potential. The surface texture is severely rough and pitted.

If localized, high severity raveling and weathering can be corrected with a patch. If extensive, however, an overlay will probably be needed. Following is a photograph of high severity weathering and raveling.



High severity weathering and raveling.

### *Shoving of AC Pavements by PCC Pavements*

Pavement expands as its temperature increases. Due to its greater strength, when PCC pavement expands adjacent to AC pavement it can sometimes cause a permanent vertical deformation in the AC pavement. Additionally, PCC pavement has a tendency to grow as gradual openings at the joint widen and are filled with incompressible material or distresses such as Alkali Silica Reactivity (ASR) cause the pavement to expand. This is referred to as pavement growth and can also produce vertical deformation in adjacent AC pavements. This deformation is called shoving.

At high severity, a large amount of shoving has occurred, causing severe roughness or break-up of the asphalt pavement. This situation can be corrected by milling the AC surface to restore smoothness and patching as needed. Installing an expansion joint may minimize the potential for recurrence of the distress. Following is a photograph of high severity shoving.



High severity shoving at AC/PCC interface.

### *Slippage Cracking*

Slippage cracking is produced when braking action or turning wheels cause the pavement surface to shift horizontally, creating crescent- or half moon shaped cracking. The cracking typically manifests in areas where soft AC surface mixes or poor bonding between AC layers exists. It is commonly found near taxiway hold lines or in areas where repeated rotating wheel loading is applied in apron areas. A full depth patch is needed to repair this distress if it is localized; if extensive, removal and replacement of the asphalt layer may be needed. The following photograph shows an example of slippage cracking.



Slippage cracking.

### *Swell*

Swell is characterized by an upward bulge in the pavement's surface. A swell may occur sharply over a small area or as a longer, gradual wave. Either type of swell can be accompanied by surface cracking. A swell is usually caused by frost in the subgrade or by swelling soil. At the high severity level, the height differential is greater than 1 ½ inches. This distress can be corrected with a patch, or, if it is an extensive problem the pavement can be reconstructed. Consideration should be made to stabilizing and draining the subgrade, and adding a frost protection layer if that is a factor.



High severity swell.

### PCC Distress Types

The following is a list of the distress type/severity combinations for PCC pavements that warrant immediate attention and/or notification of the WSDOT and the FAA about the problem. There are many other PCI distresses/severity combinations that are not mentioned herein that may be found on Washington airfields. For a complete listing of airfield PCI distresses, please refer to ASTM D 5340 or FAA AC 150/5380-6A.

#### *Blow-Ups*

Blow-ups occur in hot weather, usually at a transverse crack or joint that is not wide enough to permit expansion of the concrete slabs. The insufficient width may be caused by infiltration of incompressible materials into the joint space or an expansive aggregate problem. When expansion cannot relieve enough pressure, a localized upward movement of the slab edges (buckling) or shattering will occur in the vicinity of the joint. Blow-ups can also occur at utility cuts and drainage inlets. This type of distress is almost always repaired immediately because of severe damage potential to aircraft. Depending on the situation a full-depth patch or slab replacement will be required. An expansion joint must be provided during the repair. Following is a photograph of this distress type.



High severity blow-up in process of being repaired.

### *Corner Break*

A corner break is a crack that intersects the joints at a distance less than or equal to one-half the slab length on both sides, measured from the corner of the slab. Load repetition combined with loss of support and curling stresses usually causes corner breaks. At high severity the crack is severely spalled, causing definite FOD potential or a nonfilled crack has a mean width greater than approximately 1 inch, creating tire damage potential. This distress needs to be repaired with a full depth patch or in some cases with a slab replacement. Following is a photograph of this distress type.



High severity corner break.

*Longitudinal, Transverse, and Diagonal (LTD) Cracking*

LTD cracks divide a slab into two or more pieces. These types of cracks are usually caused by a combination of either repeated loading, curling stresses, and/or shrinkage stresses. In general, low-severity cracks are usually caused by curling and/or warping stresses and are not considered serious structural problems. Medium and high-severity cracks are usually working cracks and typically do constitute structural problems. At the high severity level, the slab will often require replacement or large full depth patches. Following is a photograph of a high severity LTD crack.



High severity LTD crack.

*Durability (D) Cracking*

“D” cracking, usually caused by a pavement’s inability to withstand the forces created by freeze-thaw cycles in concrete pavements that are susceptible to moisture penetration, can lead to the disintegration of a pavement along joints and cracks. At high severity levels, significant FOD potential can exist. A photograph of high severity “D” cracking follows.



High severity “D” cracking.

### *Patching*

A patch is an area where the original pavement has been removed and replaced by a filler material. High severity patches must be replaced. An example of a high severity patch is shown in the following photograph.



High severity patch.

### *Scaling, Map Cracking, and Crazeing*

Scaling, map cracking, and crazing are a network of shallow, fine, or hairline cracks that extend only through the upper surface of the concrete. The cracks tend to intersect at an angle of 120°. The overfinishing of the concrete surface during construction usually causes this distress. This may eventually lead to scaling which is the breakdown of the slab surface to a depth of approximately ¼ to ½ in. (6 to 13 mm). Scaling appears as a flaking away of the pavement's surface and presents a FOD potential. Other causes of scaling include improper construction, reactions to deicing salts, poor aggregate, and the impact of multiple freeze-thaw cycles. Another type of deterioration that is included in this distress category occurs when the alkalis (Na<sub>2</sub>O and K<sub>2</sub>O) in some cements react with some aggregates. One reaction of this type is known as ASR. At the high severity level, there is substantial FOD potential. Slab replacement is usually the only viable alternative. Following is a photograph of high severity scaling.



High severity scaling.

### *Faulting/Settlement*

ASTM D5340 defines settlement and faulting as a difference of elevation at a joint or crack caused by upheaval or consolidation. Instability in load transfer mechanisms, softening or loss of underlying support, or expanding materials in the subgrade are common causes of this type of distress. At the high severity level, shown in the following photograph, it can cause tire damage potential.



High severity faulting/settlement.

### *Shattered Slabs*

A shattered slab/intersecting crack distress is defined as intersecting cracks that break a slab into four or more pieces due to overloading or inadequate support, or both. The only option at the high severity level is to replace the slab. An example of a shattered slab is shown in the following photograph.



High severity shattered slab.

## **SECTION 3**

# **DEVELOPING AND IMPLEMENTING A PAVEMENT MAINTENANCE AND REHABILITATION PLAN FOR YOUR AIRPORT**

### **3. DEVELOPING AND IMPLEMENTING A MAINTENANCE AND REHABILITATION PLAN FOR YOUR AIRPORT**

In addition to this Pavement Management Manual, you received an individual pavement management report for your airport. This section of the manual provides information on how you can use the information in the individual report to prepare a maintenance and rehabilitation plan for your airport.

#### **Developing a Maintenance and Rehabilitation Plan**

Using a sample airport, following is an approach for using your individual report to develop your maintenance and rehabilitation plan. The first step is to get out your individual report, which contains the following sections:

- Pavement Inventory
- Pavement Evaluation
- Pavement Maintenance and Rehabilitation Program
- Public Law 103-305 (NPIAS airports only required; however, highly advisable for non NPIAS airports to also meet the requirements of this law)

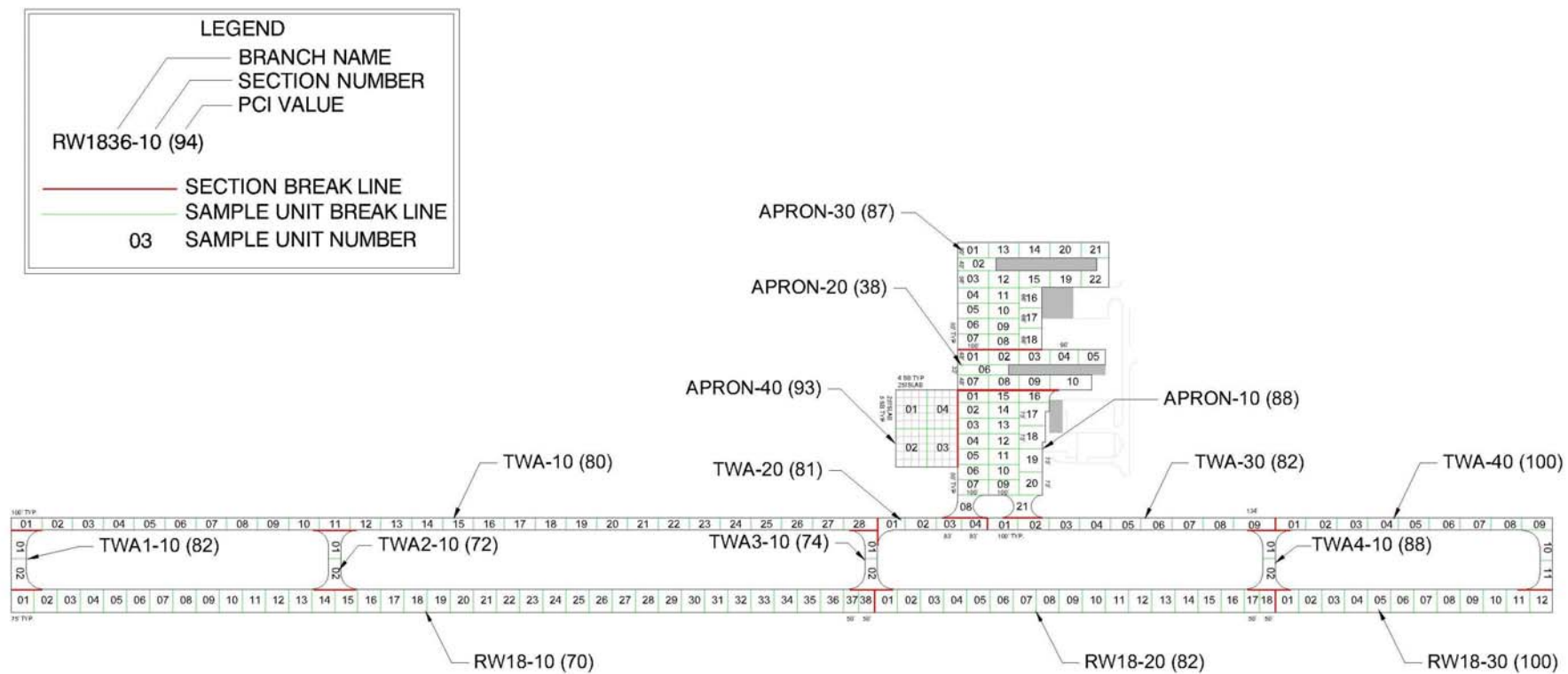
Using this report, in conjunction with your individual airport pavement management report, you will complete the following steps.

1. Determine current pavement inventory and pavement conditions.
2. Identify cause of deterioration and determine appropriate repair action.
3. Develop short-term localized maintenance plan.
4. Develop long-term rehabilitation plan.
5. Develop plan for tracking condition and maintenance.
6. Work closely with the FAA and WSDOT Aviation to obtain funding for maintenance and rehabilitation if needed.
7. Implement plan.

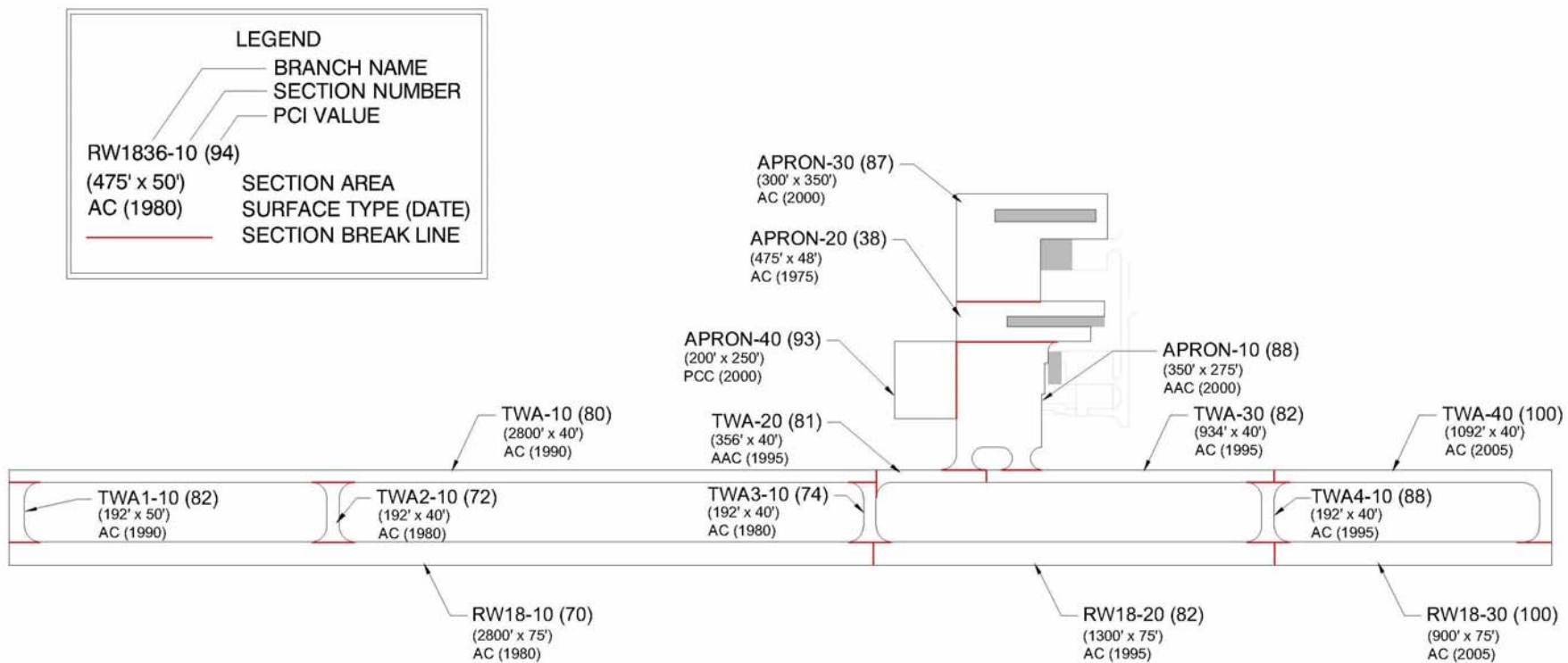
#### **Determine Current Pavement Inventory and Pavement Conditions**

Using the individual report, review the pavement infrastructure that you are responsible for managing – you are interested in the physical location of the pavements, the cross-section and age of the pavements, and their 2005 pavement condition. Your individual report contains maps showing all this information; a set of these maps for a sample airport are provided on the following three pages.

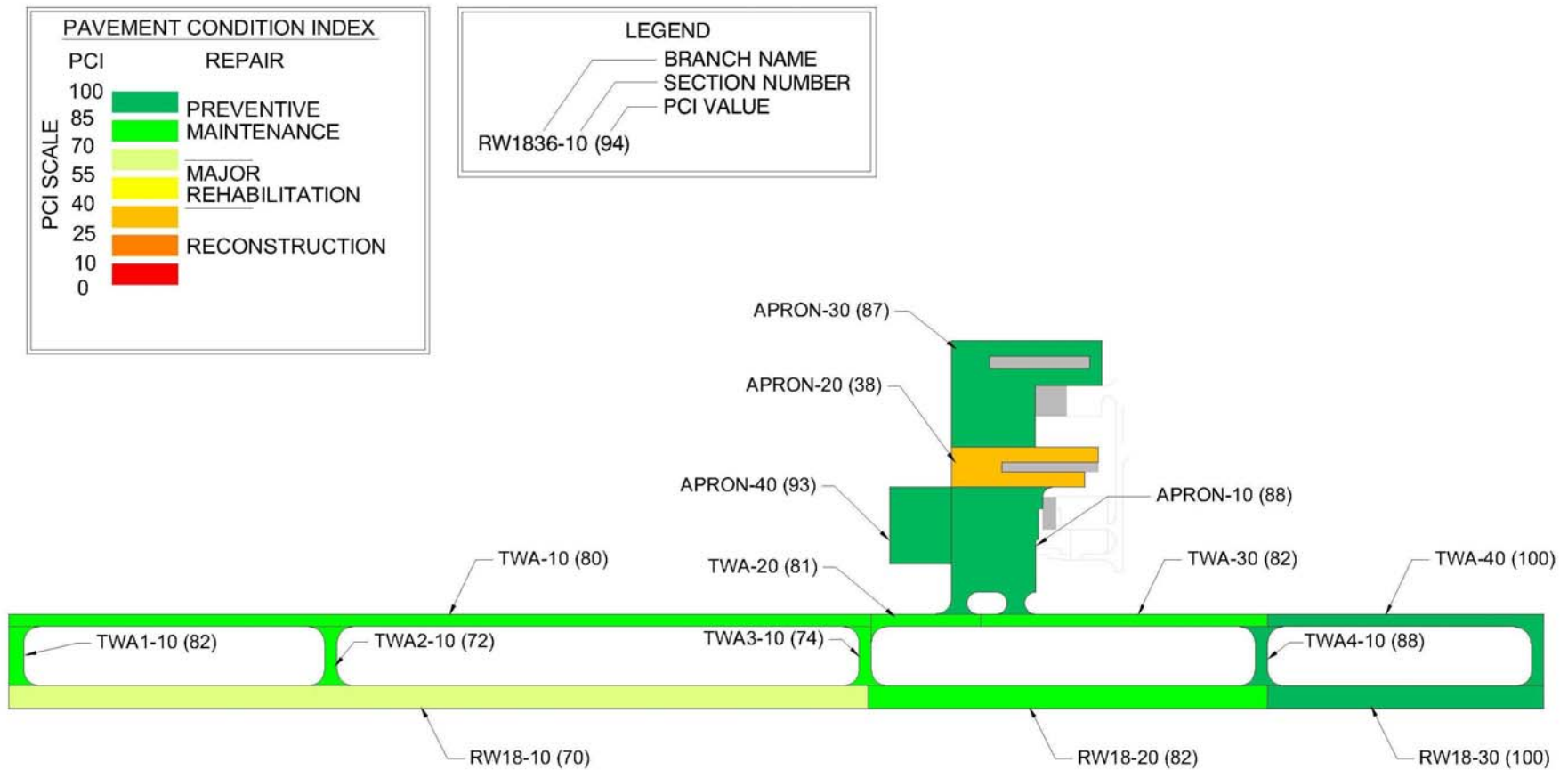
The first map is a network definition map, showing you the location of the pavements at the airport and breaking that pavement system down into management units. The second map is a work history map illustrating the type of pavement, dimensions, and age for each area. The third map is a PCI map, showing the pavement condition of the different pavement areas.



Sample network definition map.



Sample work history map.



Sample pavement condition map.

### Identify Cause of Deterioration and Appropriate Repair Action

Table 1 of your individual report provides detailed information on the 2005 pavement inspection results. It not only provides you with an overall pavement condition index for each pavement area, but also describes the type of distresses present and the percent of those distresses that are due to load, climate/durability, or other causes. For more detailed information on pavement distresses observed at your airport, you can refer to Appendix D of the report.

Using this information, you can determine the cause of deterioration and identify appropriate feasible repair actions. Appendix A of your individual report contains AC 150/5380-6A in its entirety, which provides guidance on what repairs are appropriate for different distress types as well as specific guidance on how to actually conduct the repair. Appendix B of your individual report provides information on the cause of pavement distress.

### Develop Short-Term Localized Maintenance Plan

In your individual report, Appendix F contains a 1-year localized maintenance plan for your airport. This was prepared using the maintenance policies and unit costs shown in Appendix E of that report. **These were developed for the entire state; therefore, you need to adjust them as necessary for your airport.** Following is a sample table showing the adjustments that were made due to local conditions and costs.

The short-term localized maintenance plan will need to be revisited each year, since it is not possible to predict year to year the exact needs that you will face with respect to crack sealing, patching, and so on.

Branch	Section	Distress Type	Severity	Distress Quantity	Unit	Maintenance Action	Estimated Cost
RW18	<del>10</del>	Longitudinal & Transverse cracking	Medium	450	LF	Crack Sealing - AC	\$3,802
		<del>Depression</del>	<del>High</del>	<del>150</del>	<del>SF</del>	<del>Patching - AC Deep</del>	<del>\$960</del>
<del>RW18</del>	<del>20</del>	Longitudinal & Transverse cracking	Medium	75	LF	Crack Sealing - AC	<del>\$634</del>
		<del>Depression</del>	<del>High</del>	<del>150</del>	<del>SF</del>	<del>Patching - AC Deep</del>	<del>\$960</del>
TWA	10	Longitudinal & Transverse cracking	Medium	1,733	LF	Crack Sealing - AC	\$14,637
		<del>Depression</del>	<del>High</del>	<del>160</del>	<del>SF</del>	<del>Patching - AC Deep</del> <sup>COMPLETED 12-10-05</sup>	<del>\$1,138</del> <sup>\$1,024</sup>
TWA	20	Longitudinal & Transverse cracking	Medium	198	LF	Crack Sealing - AC	\$1,673
TWA	30	Longitudinal & Transverse cracking	Medium	190	LF	Crack Sealing - AC	\$1,605
TWA1	10	Longitudinal & Transverse cracking	Medium	230	LF	Crack Sealing - AC	\$1,944
TWA4	10	Longitudinal & Transverse cracking	Medium	209	LF	Crack Sealing - AC	\$1,766
APRON	10	Longitudinal & Transverse cracking	Medium	1,508	LF	Crack Sealing - AC	\$12,743
APRON	30	Depression	Medium	150	SF	Patching - AC Deep	\$960

RW18-10+20 scheduled for 2006 Rehab. These can be removed.  
 ALSO, RW18-10 DEPRESSION FIXED 12-10-05 (\$1,063) for Safety Reasons.

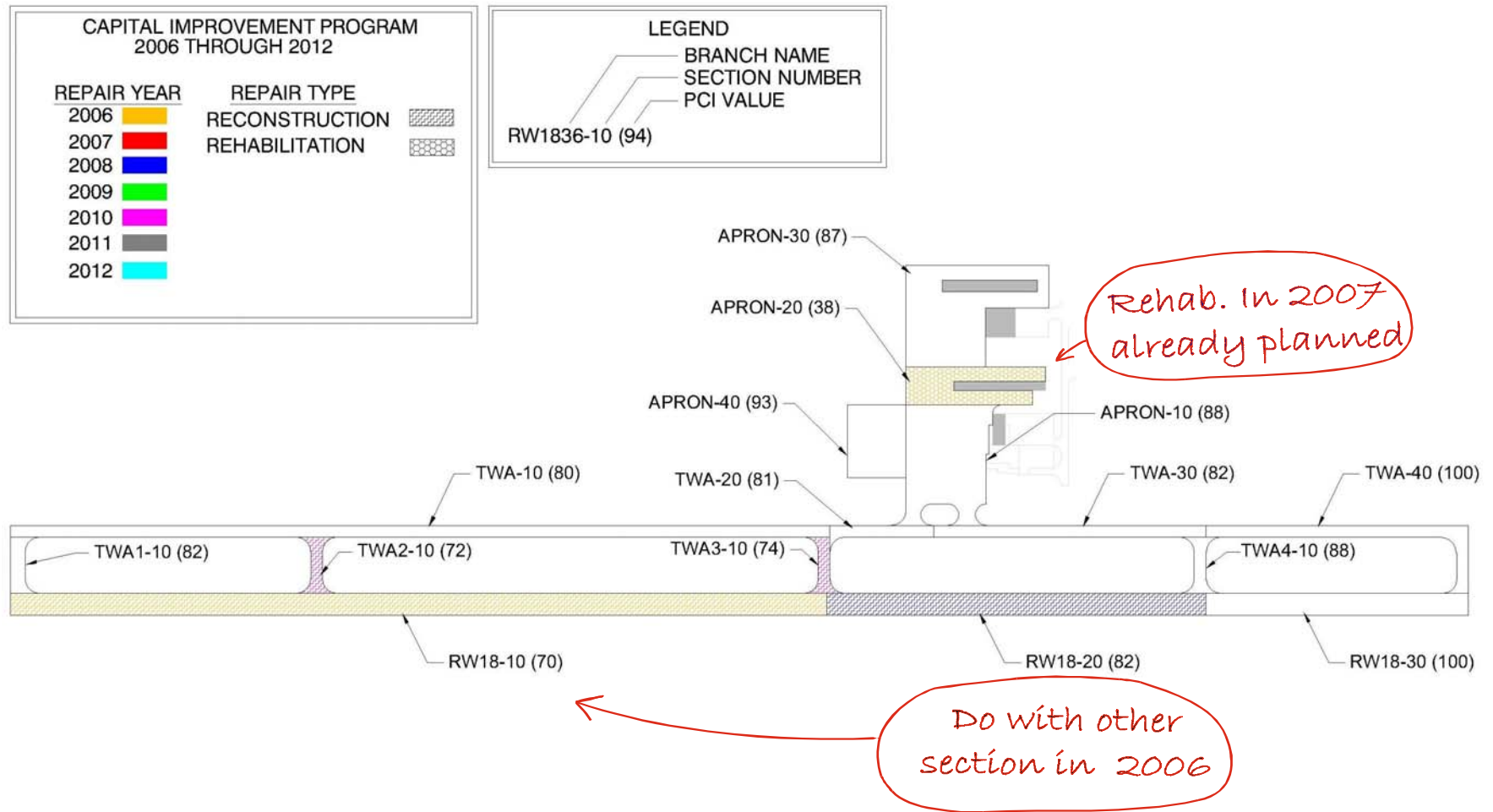
Sample adjusted localized maintenance plan.

### Develop Long-Term Rehabilitation Plan

In your individual report there is a recommended work plan. **This plan was prepared using costs developed for airports of a similar size and geographic region to yours, but are not specific to your airport. Therefore, they may need to be adjusted.**

In addition, the plan was developed using an unlimited budget analysis. The only adjustment of the plan that was made was to group “logical” groups of projects together. For example, it is possible a portion of a runway was initially recommended for work in one year and a portion for work in another year. In that case, the plan was adjusted to combine the work into a common work year. However, no adjustment was made to take into account economic constraints.

**Therefore, you will probably have to adjust the work plan presented in your individual report to phase the work so that it can be funded.** The following figure shows how the sample airport rehabilitation plan was adjusted to group logical projects together and to phase the work.



Sample adjusted work plan map.

**Develop Procedure for Monitoring Pavement Condition and Tracking Maintenance**

For NPIAS airports it is required, and for non NPIAS it is highly recommended, that you monitor pavement condition and track pavement-related maintenance needed and performed at your airport. At least monthly, you should perform a drive-by inspection of your airport pavements. During this inspection, note the distresses observed, maintenance needed, and maintenance that has been performed since the last inspection. A sample filled out inspection sheet is provided in the following figure. It is recommended that you put each month's filled out sheet in a 3-ring binder.

# **PAVEMENT INSPECTION REPORT**

Inspected By: H. SMITH

Date Inspected: 11-5-05

Inspection Record		Maintenance Action		
Location (see figure 4)	Distress Description/Dimensions/Severity/Recommended Action	Description of Repair	Date Performed	Cost
R/W 18-10	L+T CRACK w/ DEPRESSION, 2 ft. WIDE BY 75 ft. LONG. HIGH SEVERITY (2" DEEP). PATCH AREA.	FULL DEPTH REMOVAL AND REPLACEMENT (AC DEEP PATCH)	12-10-05	\$1,063
TWA-10	L+T CRACK w/ DEPRESSION (2 locations) 2' WIDE x 40' LONG. HIGH SEVERITY (2" DEEP PATCH BOTH LOCATIONS).	REMOVE & REPLACE AREA w/ PATCH (AC DEEP PATCH)	12-10-05	\$1,138

Figure 6. Sample pavement inspection report.

### Request Funding for Pavement Maintenance and Rehabilitation

If you do not have adequate local funding for the work needed, you will need to put together a strategy for obtaining funding. Depending on your airport, you may have federal or state funding available to you.

#### *Federal Funding*

To be eligible for Federal funding your airport must be in the NPIAS. If it is in the NPIAS, you are eligible for Federal funding as described below.

### General Aviation Non-Primary Entitlement Program (NPE)

General aviation non-primary airports in the NPIAS with funding requests on record are currently eligible to receive NPE funds. An airport is currently limited to 20 percent of their 5-year CIP on file with the FAA or \$150,000, whichever is less. However, these amounts may change in the future as available funding fluctuates. It is permissible for airports to bank up to 3 years of this money to have a maximum of \$600,000 in the fourth year to use. It is critical that if you want to pursue this source of money that you keep your 5-year CIP with the FAA up to date.

These NPE funds can be used for pavement maintenance and other select maintenance work. These funds can also be used for other projects that are eligible under the Airport Improvement Program (AIP) Grant program.

The following types of maintenance work are eligible for NPE money:

- Crack cleaning, filling, and/or sealing of longitudinal and transverse cracks,
- Grading pavement edges,
- Maintaining drainage systems,
- Pavement patching,
- Seal coats, and
- Remarking paved areas.

The following types of maintenance work are not eligible for NPE money:

- Sweeping,
- Snow and ice removal,
- Rubber removal, and
- Mowing turf runways.

### Airport Improvement Program (AIP) Grant

NPIAS airports are eligible to receive AIP grants for pavement-related work. Under Vision 100, 95 percent of these AIP grants are paid by the FAA. AIP funds are eligible for many activities, including pavement construction, reconstruction, and rehabilitation.

To be eligible to use AIP grant money for maintenance, the airport must be able to show that is unable to fund maintenance under its Grant Assurances using its own resources. The airport

must also agree to undertake and keep current at least the minimum pavement maintenance program as required by the FAA. And, if the sponsor of a maintenance project is a State aviation agency, PCI shall be a current part of the State's airport system planning. Maintenance projects are not funded where the region determines a rehabilitation or reconstruction project is required because pavement condition has deteriorated to such a point that a maintenance project would not be considered cost effective.

### *State Funding*

At least 65 percent of WSDOT Aviation grants are used for airport paving projects. The maximum grant amount per airport is \$250,000. To be eligible your airport must have an approved airport layout plan and be publicly-owned. If you are a NPIAS airport, you must apply first to the FAA for funding, and then Aviation will consider providing a match to that amount. Currently, the state match is 2.5 percent. Non NPIAS airports are required to provide a minimum 5 percent match. As funding becomes more competitive, the maximum grant amount and the percent of the state match may change. In prioritizing projects, runways receive the highest priority. Pavement preservation projects are considered a higher priority than new construction.

### *Implement the Plan*

Now you have a plan for preserving and rehabilitating your airport pavements – both in the short- and the long-term. It is now up to you to implement the plan!